From Precision Hardware to Open Ecosystem: BDS Global Practices and eSurvey's Vision for Empowering Sustainable Geomatics

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Key words: BeiDou Navigation Satellite System (BDS), Sustainable Development Goals (SDGs), Open Ecosystem, Precision GNSS, Global Geomatics, Surveying Technologies.

SUMMARY

High-precision geomatics is essential for achieving the United Nations Sustainable Development Goals (SDGs)[3], yet its global implementation faces a "*precision divid*e", a gap in access to affordable and adaptable technologies. This paper advocates a paradigm shift from closed, proprietary hardware systems toward open, collaborative ecosystems as the key to bridging this divide. Through a dual-perspective case analysis, the paper first examines China's BeiDou Navigation Satellite System (BDS) as an open global infrastructure, supported by its integrated industrial chain, and highlights landmark international projects worldwide. It then traces the development of eSurvey, a global GNSS brand, detailing its concrete contributions to specific SDGs, such as advancing Zero Hunger (SDG 2) through precision agriculture in Turkey and Kazakhstan, and promoting Industry, Innovation and Infrastructure (SDG 9) via digital construction in Saudi Arabia. Building on these cases, the study outlines eSurvey's roadmap to evolve into an open ecosystem architect, proposing a three-tier model encompassing open hardware, software, and collaborative networks. In conclusion, it issues a pledge and a call to action for the FIG community to co-create standards, share knowledge, and strengthen capacities, working collectively toward an inclusive and sustainable geospatial future in which precision empowerment is universally accessible.

高精度地理空间信息是实现联合国可持续发展目标（SDGs）的基础，然而，可负担、可定制技术的获取途径有限，SDG 在全球影响力受到“精度鸿沟”的阻碍。本文主张，实现从封闭的专有硬件系统向开放、协作的生态系统的范式转变，是弥合这一鸿沟的关键。通过案例研究，本文首先审视了中国北斗卫星导航系统（BDS）作为开放的全球基础设施及其支撑产业链的作用，并列举了北斗标志性国际项目。其次，本文分析了全球 GNSS 品牌 eSurvey 的发展路径，详细阐述了其对具体 SDGs 的实际贡献-例如通过土耳其和哈萨克斯坦的精准农业助力零饥饿（SDG 2），以及通过沙特阿拉伯的数字建造促进产业创新（SDG 9）。在此基础上，本文提出了 eSurvey 向开放生态系统构建者转型的蓝图，包括开放硬件、软件和协作网络的三层模型。最后，本文以一项承诺和对FIG社群的行动呼吁作结，倡议共同制定标准、分享知识和建设能力，携手共创一个普惠、可持续的地理空间未来。

From Precision Hardware to Open Ecosystem: Global Practices of BDS and eSurvey's Vision for Empowering Sustainable Geomatics

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1. INTRODUCTION

The theme of the FIG Congress 2026, "The Future We Want – The SDGs and Beyond," highlights a pivotal role of the surveying profession in tackling global challenges. High-precision geomatics provides a crucial spatiotemporal framework for objectives ranging from food security (SDG 2) to sustainable urban management (SDG 11). Yet a "*precision divide*" persists, whereby traditional, costly, and closed GNSS solutions restrict access and innovation, especially in developing regions. This paper argues that a shift toward open ecosystems, built on interoperability, collaboration, and shared innovation, is essential for inclusive and broad impact. We explore this through the global expansion of China's BeiDou Navigation Satellite System (BDS) and the tangible SDG contributions of the GNSS brand eSurvey, concluding with a vision for collaborative ecosystem development.

1.1 The Imperative of Geomatics in Achieving the SDGs

The United Nations Sustainable Development Goals (SDGs)[3] provide a universal blueprint for a more equitable and resilient future. High-precision geomatics, the science of acquiring, analyzing, and interpreting spatial and temporal data, plays a crucial role in advancing this agenda. It supports efforts ranging from monitoring agricultural land for Zero Hunger (SDG 2), mapping urban expansion for Sustainable Cities (SDG 11) to surveying forest cover for Life on Land (SDG 15), where accurate positioning and measurement are fundamental. With its 2026 Congress theme, "The Future We Want – The SDGs and Beyond," the International Federation of Surveyors (FIG) rightly places the surveying profession at the center of this global endeavor.

1.2 The Challenge: Accessibility and Innovation Bottlenecks

Despite its proven value, the full potential of high-precision geomatics remains constrained by a pervasive "*precision divide*." This divide is characterized by the global disparity in access to state-of-art Global Navigation Satellite System (GNSS) technologies. Traditional high-

precision solutions often rely on proprietary, closed hardware and software ecosystems. This model leads to high costs, vendor lock-in, and significant technical barriers to customization. Consequently, governments, small- and medium-sized enterprises (SMEs), and researchers in many developing regions find themselves unable to leverage these tools to solve local challenges, stifling innovation precisely where it is most needed for sustainable development.

1.3 A Paradigm Shift: Toward an Open Ecosystem

To bridge this precision divide and truly empower global applications, a fundamental paradigm shift, i.e. a transition from selling closed, proprietary hardware to co-creating open ecosystems, might be needed. An open GNSS ecosystem in GNSS is built on standardized interfaces, interoperable data formats, and collaborative development models. It lowers entry barriers, fosters local innovation by allowing third parties to build tailored applications, and accelerates the creation of affordable, context-specific solutions. This paper argues that such an ecosystem is not merely a technical alternative but also a necessary condition for achieving the inclusive and scalable impact required by the SDGs.

1.4 Scope and Roadmap of This Paper

This paper examines this paradigm shift through a dual-lens case study. First, it explores the role of China's BeiDou Navigation Satellite System (BDS) as a global infrastructure provider that embodies principles of openness and cooperation. Second, it analyzes the practical journey of eSurvey, a global GNSS brand under UniStrong, a leading GNSS company in China, as eSurvey evolves from a precision hardware provider toward an architect of an open ecosystem. The paper is structured as follows: Section 2 details the foundational role of BDS and China's integrated industry chain. Section 3 presents concrete case studies of how eSurvey solutions contribute to specific SDGs. Section 4 articulates the vision and blueprint for the proposed open ecosystem. Finally, Section 5 concludes with a commitment and a call for collective action within the FIG community.

2. BDS AS A GLOBAL ENABLER AND CHINA'S INTEGRATED INNOVATION

2.1 BDS: An Open and Reliable Global Infrastructure

The BeiDou Navigation Satellite System (BDS) offers open, free, and reliable positioning, navigation, and timing (PNT) services worldwide[7]. Recognized by the United Nations as a

core GNSS infrastructure, BDS is committed to openness and collaboration. This commitment is formalized in documents such as the BeiDou Navigation Satellite System Open Service Performance Standard[2], which guarantees service performance to global users. This foundational openness is the first pillar upon which a broader ecosystem can be built, providing the indispensable raw signal and basic service layer.

2.2 BDS: from Domestic to Global, Expanding International Footprint

BDS provides open, reliable global PNT services, formalized in its Open Service Performance Standard[2]. This openness is amplified by a robust domestic industry. In 2024, China's satellite navigation sector reached an output value of RMB 575.8 billion, with a complete industrial chain from chips to applications[2]. This synergy fuels BDS' international footprint, transitioning from equipment sales to systemic capacity building. Some key projects include:

Various International BDS/GNSS Applications[5]

- The Pakistan National Positioning Service Network Phase I (2014), enhancing local GNSS service accuracy.

The Construction of the Pakistan National Positioning Service Network (Phase I) (Credit: UniStrong)

- The China-Arab States BDS/GNSS Center in AICTO (2018), a hub in Tunisia for technology demonstration and training.

The Inauguration Ceremony of China-Arab States BDS/GNSS Center in AICTO (Credit: China Satellite Navigation Office)

- The Algeria Nationwide CORS Network (2023), enabling smart agriculture.

At the moment, BDS has been applied in over 140 countries and regions, demonstrating a model of cooperative infrastructure development[6].

2.3 Synergy and Scale: China's Mature GNSS Industry Chain

The rise of BDS has been synergistically supported by the rapid maturation of China's domestic satellite navigation and location service industries. According to the 2025 China Satellite Navigation and Location Service Industry White Paper[2], the total output value of the industry reached RMB 575.8 billion (approximately USD 82.5 billion) in 2024. The industry boasts a complete and integrated ecosystem, spanning from core technologies like RF chips and baseband algorithms, through receivers and antennas, to end-user applications and platform services. This scale and vertical integration enable rapid technological iteration, cost optimization, and the mass production of reliable components, which forms crucial factor for making high-precision technologies more accessible globally.

3. CASE STUDIES: ESURVEY'S GLOBAL CONTRIBUTIONS TO IMPLEMENT SDGS

eSurvey leverages BDS/GNSS technologies to deliver tangible solutions for sustainable development. The following case studies detail how its products and systems address specific challenges outlined in the UN SDGs, demonstrating a transition from providing precision tools to enabling impactful outcomes.

3.1 SDG 2 (Zero Hunger) & SDG 12 (Responsible Consumption): Revolutionizing Precision Agriculture

The global agricultural sector faces dual pressures of increasing food demand and the necessity for sustainable resource management. Precision agriculture, enabled by centimeter-level GNSS guidance, is key to enhancing productivity while minimizing environmental footprint. The BDS/GNSS-based auto-steering and variable-rate application systems, built by eSurvey and its parent company UniStrong, are at the forefront of this transformation.

In Tunisia, a tractor equipped with the BDS/GNSS-based auto-steering system was successfully demonstrated in March 2019.

The BDS/GNSS-based Auto-steering System in Tunisia (Credit: UniStrong)

In Turkey, the deployment of precision agricutural systems has garnered significant local attention. As reported by KOY Television, farmers utilizing this technology have achieved more precise planting patterns and efficient fertilizer distribution, leading to notable reductions in input costs and improvements in crop uniformity.

The BDS/GNSS-based Auto-steering System in Turkey (Credit: Köy TV Fuar)

Similarly, in the vast farmlands of Kazakhstan, eSurvey's solutions support large-scale mechanized farming, helping to optimize field operations and manage resources across extensive acreage. Beyond individual machines, the infrastructure for smart farming is being built at a national scale.

The BDS/GNSS-based Auto-steering System in Kazakhstan (Credit: eSurvey)

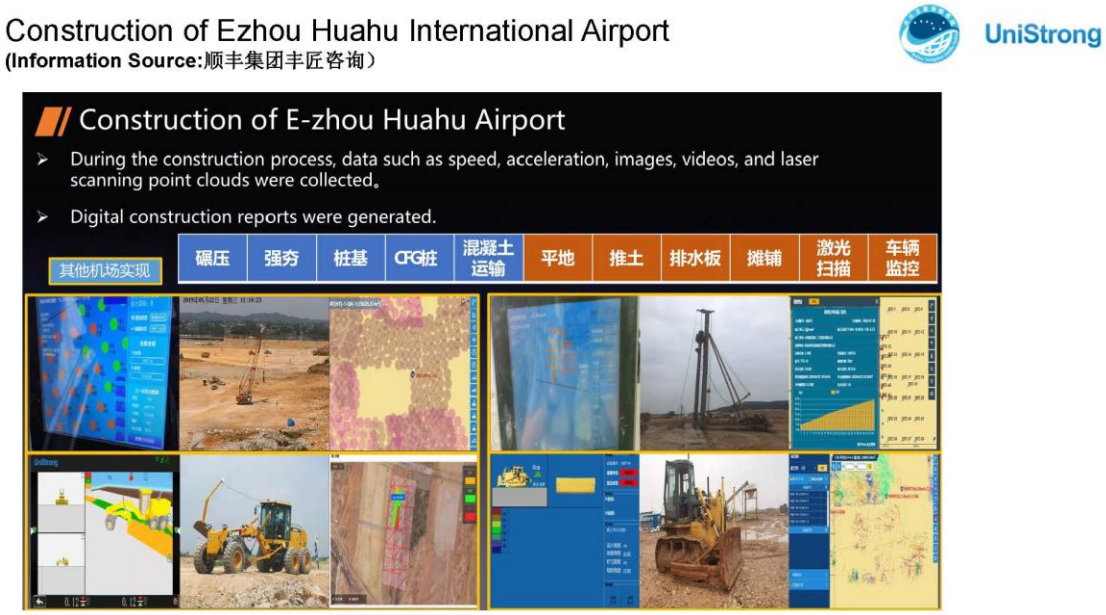
The BDS/GNSS equipped public infrastructures are fundamental for advancing smart agriculture services, enabling everything from automated machinery guidance to precise field mapping and yield monitoring for farmers, thereby contributing to both economic and environmental sustainability.

3.2 SDG 9 (Industry, Innovation and Infrastructure): Enabling Digital Construction

A modern, resilient infrastructure requires unprecedented levels of accuracy and efficiency during construction. High-precision GNSS technologies are critical for the digitalization of construction sites, enabling machine control and as-built verification. eSurvey's robust RTK solutions have been instrumental in several landmark projects.

Domestically, BDS/GNSS-based high-precision technologies played a vital role in projects like the construction *Hubei Ezhou Civil Airport,* a key national infrastructure project. In the Ezhou Airport construction process, GNSS-guided machinery ensured millimeter-level accuracy in earthmoving and pavement work for the flight zone, significantly reducing rework and material

waste, and accelerating the project timeline. The project was completed with a 35% reduction in time and a 30% reduction in cost, representing cost saving of RMB 30 billion[5].



Construction of Ezhou Huahu International Airport[5] (Credit: SF Express/Fengjiang Consulting)

On the international stage, eSurvey technologies contributed to shaping urban landscapes. In Saudi Arabia, the massive "Jeddah Downtown" development, a part of the Kingdom's Vision 2030, utilized eSurvey's solutions for layout, grading, and machine control. The reliability of these systems in demanding environments ensured that construction proceeded according to precise digital plans, enhancing safety, quality, and the overall pace of development.

A Geodetic Survey in Progress for the "Jeddah Downtown" Project (Credit: eSurvey)

These cases exemplify how GNSS high-precision positioning acts as the foundational “invisible hand” guiding the construction of the physical foundations for sustainable industry and innovation.

3.3 SDG 13 (Climate Action), SDG 14 (Life Below Water) & SDG 15 (Life on Land): Safeguarding the Environment through Monitoring

Proactive environmental monitoring is essential for disaster prevention, resource protection, and climate adaptation. eSurvey’s integrated monitoring solutions provide continuous, automated data on geological and structural stability.

An eSurvey’s Integrated Monitoring Station (Credit: eSurvey)

A critical application is seen in Turkey’s Kahramanmaraş Province, a region with significant mining activity. At a major open-pit mine, eSurvey has deployed a comprehensive slope monitoring system. This system utilizes a network of GNSS sensors and other instruments to provide real-time, millimeter-scale measurements of ground displacement. By enabling early detection of potentially unstable slopes, this technology is vital for preventing catastrophic landslides, protecting workers’ lives, minimizing environmental damage from mining operations, and ensuring the long-term stability of the land.

This case directly supports responsible resource extraction and land management (SDG 15), while broader technologies are applicable to monitoring coastal erosion (SDG 14) and infrastructure threatened by climate-induced extreme weather (SDG 13).

4. THE FUTURE PATH: FROM A GLOBAL PRODUCT PROVIDER TO AN OPEN ECOSYSTEM ARCHITECT

While a diverse product portfolio serves broad needs, localized innovations require a more flexible model. eSurvey's strategy is to evolve into an ecosystem architect via a three-layer blueprint:

1) An open hardware platform leveraging modular designs from UniStrong's full industry chain.
2) An open software/service Layer committing to future release of APIs and SDKs to empower developer-led customization, supported by an active global partner program.
3) A collaborative Innovation Network proposing joint labs and co-development initiatives with the FIG community to tackle regional SDG challenges. We call upon FIG members to collaborate on application-specific standards, share regional challenge datasets, and engage in joint capacity-building programs to transform the precision divide into a bridge of innovation.

4.1 The Limitation of a Solely Product-Centric Model

The global case studies presented in Section 3 validate the demand for high-precision GNSS solutions across diverse SDG-related sectors. However, they also reveal the inherent limitations of a traditional product-centric model. For eSurvey, even with a portfolio of over 100 hardware products serving 40+ industries, standardized offerings cannot perfectly address the infinite variety of localized workflows, integration requirements, and unique challenges faced by users in different parts of the world. To truly democratize innovation and achieve mass customization at a global scale, a more flexible and participatory model is necessary.

4.2 The eSurvey's Blueprint for an Open GNSS Ecosystem

To address this limitation issue, eSurvey is formulating a strategic evolution from a product provider to an ecosystem architect. Our blueprint envisions a three-layered open ecosystem:

1) *An open hardware platform:* Leveraging UniStrong's complete industrial chain capabilities, ranging from chips and boards to finished devices, we are working toward more modular and standardized hardware designs. This will allow partners and larger integrators to more easily adapt core GNSS engines to specialized form factors or ruggedized requirements for unique applications.

2) *An open software and service layer***:** Our commitment is to progressively release open Application Programming Interfaces (APIs) and Software Development Kits (SDKs). This will empower third-party developers, research institutions, and local solution providers to build custom applications upon our reliable positioning data stream, integrating it seamlessly with local data systems, business logic, and user interfaces. Our ongoing global partner program is the first step in fostering this layer of collaboration.
3) *A collaborative innovation network*: The ultimate goal is to foster a global network of co-creation. We propose initiatives such as joint innovation labs with universities, solution co-development programs with local integrators in key markets, and knowledge-sharing platforms within the FIG community. This network would accelerate the incubation of solutions tailored to regional SDG priorities, from water management in Africa to forestry monitoring in Southeast Asia.

4.3 A Call to Action for the FIG Community

Building such an ecosystem cannot be the endeavor of a single company. It requires collective wisdoms and efforts of the global geomatics community. We hereby extend a call to action to all FIG members, including national associations, academic institutions, and industry peers:

1) To collaborate on defining interoperable standards for specific application domains (e.g., precision agriculture data formats, construction site data protocols).
2) To share regional challenge briefs and benchmark datasets that can guide ecosystem developers toward the most pressing real-world problems.
3) To participate in joint capacity-building programs that combine technical trainings with local institutional knowledge, empowering the next generation of surveyors and developers.
4) Through such concerted efforts, we can transform the “precision divide” into a “bridges of innovations”.

5. CONCLUSION AND COMMITMENT: CO-CREATING AN INCLUSIVE FUTURE

The synergy of BDS’ open infrastructure and eSurvey’s field applications demonstrate the high-precision GNSS’ vital role in advancing the SDGs. Maximizing this potential necessitates a collective move toward open ecosystems. eSurvey pledges to drive this transition by advancing open interfaces, deepening co-development partnerships, and championing collaborative models within industry forums. We envision the FIG community as the nexus for this transformation. By pooling expertise and fostering open cooperation, we can ensure the benefits of precise geomatics are universally shared, co-creating the sustainable future envisioned by the FIG Congress.

5.1 Synthesis

This paper has articulated a vision for the future of sustainable geomatics. It has demonstrated, through the global deployment of BDS and the practical field applications of eSurvey solutions, that high-precision GNSS technologies are a potential tool for advancing the UN SDGs. However, it has also argued that maximizing this impact necessitates a shift from closed, proprietary systems to open, collaborative ecosystems. Such ecosystems are key to unlocking localized innovations, improving affordability, and ensuring that the benefits of technological progress are shared equitably across all regions.

5.2 The eSurvey's Pledge

As a practitioner and innovator in this field, eSurvey pledges to actively drive this transition. We commit our resources and expertise to:

1) Advancing the openness of technical interfaces, with a clear roadmap for releasing developer tools and documentation.
2) Deepening our partnership models, moving beyond transactional relationships to strategic co-development, particularly in support of SDG-related projects in developing regions.
3) Championing collaborative innovation models within industry forums and standards bodies, starting with the participation in the FIG Congress 2026.

5.3 Vision for Collaboration

The journey from precision hardware to an open ecosystem is a collective one. We envision a future where the FIG community serves as the nexus for this transformation, a platform where shared challenges meet shared solutions. By pooling our expertise, aligning our standards, and fostering an ethic of open cooperation, we can ensure that the power of precise positioning is available to every surveyor, every farmer, every city planner, and every environmental steward on the planet. Let us begin this essential work together, here at FIG Congress 2026, to co-create the inclusive and sustainable future we all want.

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BIOGRAPHICAL NOTES

Jun Shen received his Ph.D. degree in Computer Science from the University of Waterloo, Canada, in 1993, and his EMBA degree from the University of Southern California, USA, in 2000. Over the past 40 years, he has held various important academic, technical, and managerial positions in the fields of information technology, satellite communications and navigation, and has published more than 120 technical papers and books. Currently, Dr. Shen is the Chief Scientist of Beijing UniStrong Science & Technology Co., Ltd. He also serves as the Deputy Director of the International Cooperation Center of the China Satellite Office, an expert of the Shanghai BDS Navigation and Location Service Key Laboratory, and an adjunct professor at universities including Zhejiang University and Beihang University. In addition, he holds positions in several international professional committees, currently serving as a technical advisor to the Navigation System Panel of the International Civil Aviation Organization, and as the co-chair of Application Working Sub-Group and the Disaster Risk Reduction Task Force of the United Nations International Committee on Global Navigation Satellite System (ICG).

Xiaobin (Max) Ma was graduated with an MSc in Engineering Surveying and Geodesy from the University of Nottingham, UK, in 2011. Since entering the geospatial industry, he has

gained rich product management experience and has been directly engaged in multiple product portfolios, such as surveying and mapping, precision agriculture, UAV, Lidar and more. Currently, he is the general manager of Shanghai eSurvey GNSS Co., Ltd.

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